for response ending November 30, 2002. Claims 1, 3-8, 15-18, 20-23, 26-27, 29-35 remain pending, and claims 2, 9, 10-14, 19, 24-25, 28 and 36-44 have been canceled without prejudice. Entry of this amendment, reconsideration, and allowance of all claims are respectfully requested.

First, Applicants note that on the initialed Form-1449, the Examiner indicated that a number of references were not provided. Applicants do not understand how some of the references were provided, while others were not. In any event, and for consideration by the Examiner, enclosed herewith is another copy of each of the references that are indicated as "not provided".

In paragraph 2 of the Office Action, the Examiner rejected claims 2, 7, 17, 21, 27 and 28 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In paragraph 3 of the Office Action, the Examiner states that claims 2 and 27 show the first material as being patterned and filled with the second material. Considering the relationship with claim 3, the first material (see Figure 2) is 56 and the second is 58. The Examiner states that claims 2 and 27 recited the first index is greater than the second but claims 7 and 28 recite the first material as being SiO_2 and the second as Si_3N_4, which have indices opposite to that claimed. The Examiner noted that the layers do not appear to function as claimed with the layers as shown in claims 2 and 27.

In response, claim 2 has been canceled, and claim 27 has been amended to be consistent with claim 28. As such, claims 7, 27 and 28 now fully comply with 35 U.S.C. § 112, second paragraph. With respect to claims 17 and 21, the Examiner questions what is meant by the recited phase shift. Claims 17 and 21 have both been amended to recite that the "one or more patterned regions provide a phase shift <u>relative to the non-patterned regions</u>." In view of the

foregoing, Applicants believe that pending claims 17 and 21 also now fully comply with 35 U.S.C. § 112, second paragraph.

The Examiner's remarks point out an apparent inconstancy in some parts of the specification. Applicants have made a number of minor corrections to the specification to correct for this apparent inconsistency. For example, on page 10, lines 1-2, Applicants have amended the specification to indicate that the first material layer 56 preferably has a refractive index that is <u>less</u> [greater] than the refractive index of the second material layer 58. Support for this amendment is found later in the same paragraph, where the specification states: "[I]n one example, the first material layer 56 is SiO_2, the second material layer 58 is Si_3N_4 or TiO_2, and the top mirror layer 52 is AlGaAs, ...". No new matter has been added by any of these amendments.

In paragraph 5 of the Office Action, the Examiner restricted the claims into two groups, namely: Group I which corresponds to claims 1-9, 15-18 and 20-35; and Group II which corresponds to claims 10-14, 19 and 36-44. In paragraph 8 of the Office Action, the Examiner noted that Mr. Brian Tufte made a provisional election on 20 August 2002, without traverse, to prosecute the invention of Group I. Applicants hereby affirm this election. Claims 10-14, 19 and 36-44 have been canceled as being drawn to a non-elected invention.

In paragraph 11 of the Office Action, the Examiner rejected claims 1-7 and 9 under 35 U.S.C. § 102(b) as being anticipated by Johnson, citing Figure 16 of Johnson. In response, Applicants have amended claim 1 to recite:

> 1. (Amended) A resonant reflector for an optoelectronic device <u>tuned to a wavelength</u>, the resonant reflector comprising:
>
> a first material layer <u>having a thickness of an odd multiple of a quarter of the wavelength and also</u> having a first refractive index, the first material layer having one or more patterned regions that extend down into the first material layer, selected patterned regions being filled with a second material having a second refractive index<u>, the first refractive index being less than the second refractive index</u>; and

[a mirror] <u>a third layer</u> positioned <u>immediately</u> adjacent the first material layer, the [mirror] <u>third layer</u> having [an adjacent mirror layer with] a third refractive index <u>that is greater than the first refractive index</u>.

As can be seen, claim 1 now recites that the first material layer has a thickness of an odd multiple of a quarter wave length, and has one or more patterned regions that extend down into the first material layer. Claim 1 further recites that selected patterned regions are filled with a second material, wherein the refractive index of the first material is less than the refractive index of the second material. Finally, claim 1 recites a third layer positioned <u>immediately</u> adjacent the first material layer, where the refractive index of the third layer is greater than the first refractive index.

In Figure 16 of Johnson, two SiO2 layers appear to be provided on the top layer 21 of the upper mirror structure 20. First, an un-patterned quarter wave layer of SiO_2 appears to be provided, followed by a patterned SiO_2 layer 50. Thus, the embodiment shown in Figure 16 of Johnson does not have a first material layer that has a thickness of an odd multiple of a quarter wave length that includes one or more patterned regions and is positioned <u>immediately</u> adjacent a third layer, wherein the refractive index of the third layer is greater than the refractive index of the first layer. In view of the foregoing, claim 1 is believed to be clearly patentable over Johnson. For similar and other reasons, dependent claims 3-7 are also believed to be clearly patentable over Johnson.

In paragraph 20 of the Office Action, the Examiner rejected claims 23-28 and 31-35 under 35 U.S.C. § 102(b) as being anticipated by Corzine et al. In response, Applicants have amended claim 23 to recite:

23. (Amended) A resonant reflector for an optoelectronic device that has an optical cavity with an optical axis, the resonant reflector comprising:

a resonant reflector layer extending across at least part of the optical cavity of the optoelectronic device, the resonant reflector layer having a [reflectivity] <u>refractive index</u> that does not abruptly change laterally across the optical cavity<u>;</u>

the refractive index of the resonant reflector layer including contributions from a first material having a first refractive index and a second material having a second refractive index, at least one of the first material and the second material being a polymer.

As can be seen, claim 23 now recites that at least one of the first material and the second material is a polymer. The "polymer" limitation recited in claim 23 was also recited in originally presented claim 29. It does not appear that the Examiner specifically rejected originally claim 29, and nothing in Corzine et al. appears to suggest such a limitation. Accordingly, claim 23 as amended is believed to be in condition for allowance. For similar and other reasons, dependent claims 26-27, and 29-33 are also believed to be in condition for allowance.

With respect to independent claim 34, Applicants have amended claim 34 to recite:

> 34. (Amended) A resonant reflector for an optoelectronic device that has an optical cavity with an optical axis, the resonant reflector comprising:
> a resonant reflector layer having two substantially planar opposing surfaces extending across at least part of the optical cavity of the optoelectronic device, the resonant reflector layer having a first region with a first refractive index and a second region with a second refractive index, the first region and the second region co-extending along an interface, at least part of the interface being not parallel to the optical axis.

As can be seen, claim 34 has been amended to recite that the resonant reflector layer has two substantially planar opposing surfaces extending across at least part of the optical cavity (Emphasis Added). This amendment is supported by the present specification at, for example: page 7, lines 2-3; page 14, lines 12-15; page 15, lines 20-21; page 16, lines 24-25; Figures 6, 7C, 8D and 9D. Nothing in Corzine et al. appears to suggest this limitation. Instead, it appears that Corzine et al. suggest providing a non-planar upper surface (i.e. concave or convex), as shown in, for example, Figures 1A, 1B, 2, 3A-3B, 4A-4D, 7A-7J. In view of the foregoing, Applicants believe that claim 34 is clearly in condition for allowance. For similar and other reasons, Applicants believe that dependent claim 35 is also in condition for allowance.

In paragraph 30 of the Office Action, the Examiner rejected claim 8 under 35 U.S.C. § 103(a) as being unpatentable over Johnson. For reasons similar to those given above with respect to claim 1, as well as other reasons, claim 8 is believed to be clearly patentable over Johnson.

In paragraph 32 of the Office Action, the Examiner indicated that claims 15, 16 and 18 are allowed. In paragraph 33 of the Office Action, the Examiner indicated that claim 17 would be allowable if rewritten to overcome the rejections under 35 U.S.C. 112, second paragraph, set forth in the Office Action and to include all of the limitations of the base claim and any intervening claims. Since claim 17 is now believed to fully comply with 35 U.S.C. 112, second paragraph, claim 17 is believed to be clearly in condition for allowance.

Reexamination and reconsideration are respectfully requested. It is respectfully submitted that all pending claims are now in condition for allowance, and issuance of a Notice of Allowance in due course is requested. If a telephone conference might be of assistance, please contact the undersigned attorney at (612) 677-9050.

Respectfully submitted,

Robert A Morgan et al.

By their attorney,

Date: November 25, 2002

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Version with Markings to Show Changes Made

In the Specification

The paragraph beginning at page 4, line 18, has been rewritten as follows:

The first material layer (or top mirror layer in an alternative embodiment) preferably has a refractive index that is [greater]less than the refractive index of the second material layer, and the first and second material layers preferably have a refractive index that is less than the refractive index of the top mirror layer (or next layer down in the alternative embodiment) of the optoelectronic device. This causes a reduction in the reflectivity of the resonant reflector in those regions that correspond to the etched regions of the first material layer (or top mirror layer). The difference in reflectivity can be used to provide mode control for optoelectronic devices.

The paragraph beginning at page 10, line 1 has been rewritten as follows:

The first material layer 56 preferably has a refractive index that is [greater]less than the refractive index of the second material layer 58, and the first and second material layers 56 and 58 preferably have a refractive index that is less than the refractive index of the top mirror layer 52 of the optoelectronic device 54. In one example, the first material layer 56 is SiO_2, the second material layer 58 is Si_3N_4 or TiO_2, and the top mirror layer 52 is AlGaAs, although other suitable material systems are contemplated. Each layer is preferably an [even]odd multiple of one-quarter wavelength ($\lambda/4$) thick. This causes a reduction in reflectivity of the resonant reflector 50 in those regions that correspond to the etched regions 60 (see Figure 3B) in the first material layer 56, that is, those regions that are filled with the second material layer 58. By designing the etched regions to circumscribe the desired optical cavity, this difference in reflectivity can be used to help provide mode control for VCSEL 54.

The paragraph beginning at page 11, line 6, has been rewritten as follows:

Another illustrative approach for controlling transverse modes of an optoelectronic device is shown in Figure 4. Figure 4 is a schematic cross-sectional side view of a planar, current-guided, GaAs/AlGaAs top surface emitting vertical cavity laser, as in Figure 1, with another illustrative top mounted mode control resonant reflector 70. In this embodiment, the resonant reflector 70 is formed by etching down into but not all the way through one or more of the top mirror layers 72 of the optoelectronic device. The etched region, generally shown at 74, preferably circumscribes the desired optical cavity of the optoelectronic device, and has a depth that causes a phase shift that reduces the reflectivity of the resonant reflector 70 at the desired operating wavelength, such as a depth that corresponds to an odd multiple of $\lambda/4$. To provide further differentiation, a cap mirror 76 having one or more additional layers may be provided on selected non-patterned regions 78 of the top mirror layer 72, such as over the desired optical cavity of the optoelectronic device. The cap mirror [70]<u>76</u> may include one or more periods of a conventional semiconductor DBR mirror, or more preferably, a narrow band dielectric reflection filter. A metal layer may be provided on selected regions of the top mirror layer 72. The metal layer may function as a top contact layer.

Please replace the paragraph beginning at page 13, line 24, with the following rewritten paragraph:

Figures 7A-7D are schematic cross-sectional side views showing a first illustrative method for making the resonant reflector of Figure 6. In this illustrative embodiment, a first substantially planar layer of material 94 is provided on, for example, a top mirror layer 104 of a conventional DBR mirror. The top mirror layer 104 preferably has a refractive index that is higher than the refractive index of the first layer of material 94. The top mirror layer 104 may

be, for example, AlGaAs, and the first layer of material 94 may be, for example, [TiO2, Si3N4]<u>SiO2</u>, or a polymer such as polyamide or Benzocyclobuthene (BCB).

Please replace the paragraph beginning at page 14, line 4 with the following rewritten paragraph:

The first layer of material is then patterned, as shown in Figure 7A. This is typically done using a conventional etch process. As shown in Figure 7B, the patterned first layer of material 104 is then heated, which causes it to reflow. This results in a non-planar top surface 98. Then, and as shown in Figure 7C, a second layer of material 96 is provided over the first layer of material 94. The top surface 105 of the second layer of material 96 is preferably substantially planar, but it may be non-planar if desired. The second layer of material 96 preferably has a refractive index that is [lower]<u>higher</u> than the refractive index of the first layer of material 94. The second layer of material 96 may be, for example, [SiO2]<u>TiO2, Si3N4</u>, a polymer, or any other suitable material. When desired, the top surface 105 of the second layer of material 96 may be planarized using any suitable method including, for example, reflowing the second layer of material 96, mechanical, chemical or chemical-mechanical polishing (CMP) the second layer of material 96, etc. In some embodiments, the top surface 105 is left non-planar.

Please replace the paragraph beginning on page 14, line 25 with the following rewritten paragraph:

Figures 8A-8E are schematic cross-sectional side views showing another illustrative method for making the resonant reflector of Figure 6. In this illustrative embodiment, and as shown in Figure 8A, a first substantially planar layer of material 94 is provided on, for example, a top mirror layer 104 of a conventional DBR mirror. The top mirror layer 104 preferably has a refractive index that is higher than the refractive index of the first layer of material 94. The top

mirror layer 104 may be, for example, AlGaAs, and the first layer of material 94 may be, for example, [TiO2, Si3N4]<u>SiO2</u>, or any other suitable material. Next, a photoresist layer 110 is provided and patterned on the first layer of material 94, preferably forming an island of photoresist above the desired optical cavity of the optoelectronic device.

Please replace the paragraph beginning at page 15, line 13, with the following rewritten paragraph:

As shown in Figure 8D, a second layer of material 96 is then provided over the first layer of material 94. The second layer of material 96 preferably has a refractive index that is [less]<u>higher</u> than the refractive index of the first layer of material 94. The second layer of material 96 is preferably provided over the entire top surface of the resonant reflector, and etched away in those regions where a top contact 102 is desired. Once the second layer of material 96 is etched, a contact layer 102 is provided on the exposed regions of the top mirror layer 104. The contact layer 102 provides electrical contact to the top mirror layer 104. Preferably, the top surface of the second layer of material 96 is substantially planar. As shown in Figure 8E, a cap mirror 106 may be provided above the second layer of material 96, if desired. The cap mirror 106 may include one or more periods of a conventional semiconductor DBR mirror, or more preferably, a narrow band dielectric reflection filter.

Please replace the paragraph beginning at page 16, line 17 with the following rewritten paragraph:

After the etching step, and as shown in Figure 9D, a second layer of material 96 may be provided over the first layer of material 94. Like above, the second layer of material 96 preferably has a refractive index that is [less]<u>higher</u> than the refractive index of the first layer of material 94. The second layer of material 96 is preferably provided over the entire top surface of

the resonant reflector, and etched away in those regions where a top contact 102 is desired. Once the second layer of material 96 is etched, a contact layer 102 is provided on the exposed regions of the top mirror layer 104. The contact layer 102 provides electrical contact to the top mirror layer 104. Preferably, the top surface of the second layer of material 96 is substantially planar.

In the Claims

Please cancel claims 2, 9, 10-14, 19, 24-25, 28 and 36-44, without prejudice.

Please amend claims 1, 3, 7, 8, 17, 20, 21, 23, 26, 27, 29, 31 and 34 as follows:

1. (Amended) A resonant reflector for an optoelectronic device tuned to a wavelength, the resonant reflector comprising:

a first material layer having a thickness of an odd multiple of a quarter of the wavelength and also having a first refractive index, the first material layer having one or more patterned regions that extend down into the first material layer, selected patterned regions being filled with a second material having a second refractive index, the first refractive index being less than the second refractive index; and

[a mirror] a third layer positioned immediately adjacent the first material layer, the [mirror] third layer having [an adjacent mirror layer with] a third refractive index that is greater than the first refractive index.

3. (Amended) A resonant reflector according to claim 1, wherein [further comprising a] the second material [layer having the second refractive index, the second material layer patterned to] also extends above the non-patterned regions of the first material layer.

7. (Amended) A resonant reflector according to claim 1, wherein the first material is SiO2, the second material is Si3N4 or TiO2, and the third [top DBR mirror] layer is AlGaAs.

8. (Amended) A resonant reflector according to claim 1 wherein the first material layer is a top mirror layer of a DBR [the] mirror.

17. (Amended) A resonant reflector according to claim 16, wherein the one or more patterned regions provide a phase shift relative to the non-patterned regions.

20. (Amended) A resonant reflector [according to claim 19,] for an optoelectronic device, the resonant reflector comprising:

a top mirror with a top mirror layer, the top mirror layer etched with a pattern down but not through the top mirror layer resulting in one or more patterned regions and one or more non-patterned regions, wherein the one or more patterned regions reduce the reflectivity of the resonant reflector in those regions;

a cap mirror situated above selected non-patterned regions of the top mirror layer.

21. (Amended) A resonant reflector according to claim 20, wherein the one or more patterned regions provide a phase shift relative to the non-patterned regions.

23. (Amended) A resonant reflector for an optoelectronic device that has an optical cavity with an optical axis, the resonant reflector comprising:

a resonant reflector layer extending across at least part of the optical cavity of the optoelectronic device, the resonant reflector layer having a [reflectivity] refractive index that does not abruptly change laterally across the optical cavity;

the refractive index of the resonant reflector layer including contributions from a first material having a first refractive index and a second material having a second refractive index, at least one of the first material and the second material being a polymer.

26. (Amended) A resonant reflector according to claim [25] 23, wherein the first material is confined to a first region and the second material is confined to a second region, the first region and the second region co-extending along an interface, wherein at least part of the interface is not parallel to the optical axis of the optoelectronic device.

27. (Amended) A resonant reflector according to claim [25] 23, wherein the first refractive index is [larger] less than the second refractive index.

29. (Amended) A resonant reflector according to claim [27] 23, wherein the first material is AlGaAs and the second material is a polymer.

31. (Amended) A resonant reflector according to claim [25] 23, further comprising a mirror having a top mirror layer, the top mirror layer positioned adjacent to the resonant reflector layer.

34. (Amended) A resonant reflector for an optoelectronic device that has an optical cavity with an optical axis, the resonant reflector comprising:

a resonant reflector layer <u>having two substantially planar opposing surfaces</u> extending across at least part of the optical cavity of the optoelectronic device, the resonant reflector layer having a first region with a first refractive index and a second region with a second refractive index, the first region and the second region co-extending along an interface, at least part of the interface being not parallel to the optical axis.

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FORM PTO-1449	Atty. Docket No.: 1100.1114101 (H16-26549)	Serial No.: 09/751,423
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	Applicant: Robert A. Morgan et al.	
	Filing Date: December 29, 2000	Group Art: 2872

Examiner Initial		Document No.	Date	Name	Class	Sub Class	Filing Date If Appropriate
DW	BY	5,778,018	07/07/1998	Yoshikawa et al.	372	45	
	BZ	5,818,066	10/06/1998	Duboz	257	21	
	CA	5,903,590	05/11/1999	Hadley et al.	372	96	
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	CC	5,978,401	11/02/1999	Morgan	372	50	
	CD	6,055,262	04/25/2000	Cox et al.	372	96	

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DW	CL	Jewell et al., "Surface Emitting Microlasers for Photonic Switching & Intership Connections", Optical Engineering, Vol. 29, No. 3, pp. 210-214, March 1990.

EXAMINER: Douglas Wille | DATE CONSIDERED: 27 Aug 02

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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DAW	CN	Kishino et al., "Resonant Cavity-Enhanced (RCE) Photodetectors", IEEE Journal of Quantum Electronics, Vol. 27, No. 8, pp. 2025-2034.
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EXAMINER: Douglas Wille | DATE CONSIDERED: 27 Aug 02

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DC	~~Morgan et al., "Vertical Cavity Surface Emitting Laser Arrays: Come of Age," , Invited paper, SPIE, Vol. 2683-04, OE LASE 96; Photonics West: Frabrication, Testing and Reliablity of Semiconductor Lasers, (SPIE< Bellingham, WA, 1996).~~	
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EXAMINER: Douglas Webb | DATE CONSIDERED: 22 Aug 02

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LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	Applicant: Robert A. Morgan et al.	
	Filing Date	Group Art:
	December 29, 2000	2872

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EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449	Atty. Docket No.: 1100.1114101 (H16-26549)	Serial No.: 09/751,423
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	Applicant: Robert A. Morgan et al.	
	Filing Date	Group Art:
	December 29, 2000	2872

FOREIGN PATENT DOCUMENTS

		Document No.	Date	Country	Class	Sub Class	Translation Yes No
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